What is Water Alkalinity? Why Does it Matter?

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The telephone rings. The floriculture / greenhouse Extension specialist answers the call. On the other side a grower relates that his plants have a nutritional problem: most of the leaves are turning a pale yellow, especially the new ones. The grower indicates that he is applying sulfuric acid because the pH of the water is 7.8. When the Extension specialist asks what the alkalinity of the water is, the grower replies that he has no idea. This imaginary situation is based on reality. Many Extension Educators all over the country have similar experiences: usually, growers do not have a clear understanding of what can cause increases in substrate pH, and that water alkalinity, rather water pH, is the source of the problem. What is the cause of this situation? Where is the source of the confusion?

The purpose of this article is to help growers differentiate between “high pH” and “high alkalinity”.

What is pH?

pH stands for hydrogen (H) potential and it represents a measure of the concentration of H^+ ions in a solution. (Tap water and the water in the substrate inside a container are examples of solutions.) As a mathematical consequence of the formula that defines pH, the units on the pH scale range from 0 to 14. A value of 7.0 indicates neutrality, values less than 7.0 are called *acidic,* and values greater than 7 are called *basic* or *alkaline*. Values close to 0 or 14 represent extremes *acidity* and basicity*,* respectively. In general, the pH of water for irrigating greenhouse crops should be between 5.0 and 7.0.

What is water alkalinity?

Water *alkalinity* is a measure of the concentration of bases in a solution or the ability to neutralize acids in water. It can also be referred to as the buffering capacity of water. Examples of bases are carbonates, bicarbonates, magnesium bicarbonate, ammonia, borates, phosphates, silicates, and organic bases. For all practical purposes, carbonates and bicarbonates are the main contributors to the alkalinity of water. Irrigating your crops with water high in alkalinity is similar to adding lime to the substrate.

So, we have water that is called *alkaline* if its pH is greater than 7 and it is said to have high *alkalinity* if its base concentration is high. No wonder many growers are confused like the grower in our hypothetical example above!

Now that one source of the confusion has been identified, let's look at alkalinity and irrigation water. **Water alkalinity has a large effect on substrate pH** while the **pH of irrigation water has a minimal effect on the pH of the substrate** (technically we should say: the pH of the solution in the substrate). The bottom line is that growers need to know the alkalinity of their irrigation water and based on its level, decide whether treatment is need.

The units of measure used to describe alkalinity are another possible source of confusion for growers. Alkalinity can be expressed in parts per million (ppm), milligrams per liter (mg/L) or equivalents. To make matters worse, these units can be used to express alkalinity as calcium carbonate equivalents or calcium bi-carbonate equivalents. Different laboratories use different units and it is important for growers to know which units their labs are using, especially if such a number will be used to calculate how much acid needs to be added to the irrigation water. If alkalinity units are confusing, growers should contact a local extension agent for help.

Why bother with water alkalinity?

Water alkalinity increases the pH of substrates. At high substrate pH some nutrients become unavailable to some plants even if the nutrients are present in the substrate. The most common deficiency caused by high substrate pH is iron deficiency which manifests itself with chlorosis of the leaves, especially new ones (Fig. 1 and 2).

Figure 1. Typical symptoms of iron deficiency in calibrachoa.

On the other hand, if the pH of the substrate is too, low some crops like geraniums and marigolds may suffer from an excess of nutrients (toxicity) like iron and manganese because these nutrients are easily available and easily up-taken (Figure 3). Growers in areas with very low water alkalinity should also be concerned because of the possibility of the substrate pH becoming too low. Under these circumstances, an acidic fertilizer (such as 20-10-20) can lower substrate pH.

Figure 2. Severe iron deficiency produces chlorotic (almost white) young leaves.

Figure 3. When grown at lower than normal substrate pH, marigolds have symptoms that, at first glance, can be confused with mite damage.

Water alkalinity is not a constant!

It is important to remember that water alkalinity is not a constant value. It can change seasonally, or over time. We advise growers to test their water at least once a year. In general, surface waters like from rivers and lakes, are less likely to have high alkalinity levels than water from wells. For example, if your water source is an aquifer or well, during extended periods of drought or heavy rain you may see you water alkalinity increase or decrease, respectively.

What is a high alkalinity level?

This question is difficult to answer because substrate pH is affected by several factors in addition to water alkalinity. Among these factors, we can include fertilizer acidity or basicity, the amount and type of lime added to the substrate mix prior to use, the type of substrate components, and the crop itself. The size of the container can be a factor as well because it takes less volume of high alkalinity irrigation water to affect a small volume of substrate. As a consequence, we say that water having 120 ppm alkalinity, expressed as ppm calcium carbonate, should be like a yellow flag (proceed with caution!). With values lower than 120 ppm, the chance of getting into trouble diminish. Often, with values larger than 120 ppm, the probability of having high substrate pH problems increases.

However, this is not absolute. If you are growing callibrachoa or any other pH-sensitive crop, a value of 120 ppm may be too high. If you use an acidic fertilizer, the same alkalinity value may be just fine even with the callibrachoa crop. If you are a plug producer, a value of 80 to 90 ppm may be better. (It has to be noted that we are aware of growers who, despite alkalinity values well above 120 ppm, grow healthy crops without applying any acid because they use other cultural practices to compensate such as more acidic fertilizers and/or less pre- plant lime.)

So how do you overcome high alkalinity? By correctly acidifying your irrigation water, you reduce the amount of bicarbonates (HCO_3^-) and decrease alkalinity. More precisely, acid injection neutralizes alkalinity and results in the formation of carbon dioxide (CO_2) and water (H_2O):

$\mathbf{H^+}$ (from acid) + $\mathbf{HCO_3^-}$ (in the irrigation water) --------> $\mathbf{CO_2}$ + $\mathbf{H_2O}$

Sulfuric (H_2SO_4), phosphoric (H_3PO_4), nitric (HNO_3), or citric ($H_3C_6H_5O_7$) acid are commonly injected into irrigation water to neutralize water alkalinity. Consider several factors when selecting an acid: ease of use, safety, cost, and nutrients (nitrogen, phosphorous and sulfur) provided by the acid.

How much acid to apply?

Researchers from North Carolina State University and Purdue University developed an Alkalinity Calculator using an Excel® spreadsheet (ces.ncsu.edu/depts/hort/floriculture/software/alk.html). Growers can enter their water pH and alkalinity into the spreadsheet and then select their acidifying agent of choice (sulfuric, phosphoric, or nitric acid)to reach a target pH or alkalinity. The spreadsheet also has the ability to calculate the nutrient additions from each acid and will report the acidification costs, based on the price per gallon of acid. In order to use this tool, you need to enter the alkalinity of the water, its pH, and the desired alkalinity level. Then, with a click, you will have an answer. Is that simple!

How do I know if I am adding enough acid?

Many growers measure pH of the irrigation water after it goes through the acid injector. However, this imprecise method can give the wrong answer to the problem. Growers will be better off by buying an alkalinity kit and measuring alkalinity itself. These kits are inexpensive and, if used correctly, give results that are acceptable for practical purposes.

Can I use iron chelates?

The answer might be “Yes” if you need to greenup your plants fast (e.g. before shipping them). However, this practice does not solve the root of the problem: high substrate pH. If the pH is not lowered to the appropriate level according to the crop, the iron deficiency will reappear over time leading to unhappy customers. Furthermore, iron chelates only supply iron and not the other micronutrients that may be deficient due to high pH levels of nutrients such as manganese, zinc, or copper.

How do I manage substrate pH?

As a grower, you can plot the weekly substrate pH using your normal graphical tracking tools available for height control. On the plot, you can have upper and lower decision points. It is important to remember that all nutrients are readily available at a pH of 5.4 to 6.2 in soilless substrates, but each plant species has an optimal pH range. In the Table below, we include corrective measures to either lower or increase substrate pH.

Table: Corrective measures for pH substrate

Lower Substrate pH	**Raise Substrate pH**
Proper water acidification	Discontinue water acidification
Use acid-residue (ammoniacal nitrogen) fertilizers if plants are tolerant	Use basic-residue fertilizers
Drench with aluminum sulfate to rapidly reduce pH*	Inject potassium bicarbonate*

* Should only be performed in severe cases.

Things to remember and do:

1) Understand the difference between water pH and water alkalinity.

2) Know the pH and the alkalinity of your irrigation water.
3) Remember that water alkalinity has a greater effect on substrate pH.
4) Base the amount of acid to be added to your irrigation water on its alkalinity and not on its pH.